Expressive Expression Mapping with Ratio Images

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Problem


A


A'

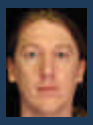

B

?

B'

- Given A, A', B
- What is B'

Possible Solution


A


A'

Geometric warping:

$$v_{B'} = v_B + v_{A'} - v_A$$


B


B'

⇐ Expression details lost

Our Solution


A


A'

Add expression details


B


B'

⇐ Our method

Basic Idea

Expression ratio image:

Captures illumination changes

- Material-independent
- Transfer (mapping) without 3D info

Related work

Expression mapping based on geometrical warping
- Williams 90:
- Litwinowicz & Williams 94:

Image morphing
- Pighin et al. 98
- Seitz & Dyer 96

Physical simulation
- Badler & Platt 81
- Waters 87
- Terzopoulos & Waters 90
- Lee et al. 95

Related work in relighting

Marschner & Greenberg 97:
- Use the ratio of synthetic image pair to modify a photo

Debevec 98:
- Similar spirit, use color difference instead

Riklin-Raviv & Shashua 99:
- Relight faceB from the relighted image of faceA

Stoschek 00:
- Combined with image morphing

Lambertian model

Assume there are *m* point light sources:

$$I = r \sum_{1 \le i \le m} S_i I_i n \cdot l_i \equiv rE(n)$$

where: $S_i = \begin{cases} 0 & \text{If the point cannot be seen from light i} \\ 1 & \text{Otherwise} \end{cases}$

Expression ratio image

Before deformation: $I = r\ E(n)$

After deformation: $I' = r\ E(n')$

Expression ratio image: $\frac{I'}{I} = \frac{E(n')}{E(n)}$

ERI:
- captures illumination changes caused by surface deformation
- is material independent

Surface deformation mapping

Two surfaces
- same normals at the corresponding points
- different materials
- same deformations

	Before deform.	After deform.
Surface 1:	$I_1 = r_1 E(n)$	$I_1' = r_1 E(n')$
Surface 2:	$I_2 = r_2 E(n)$	$I_2' = r_2 E(n')$

$$\frac{I_1'}{I_1} = \frac{I_2'}{I_2} \Rightarrow I_2' = \frac{I_1'}{I_1} I_2$$

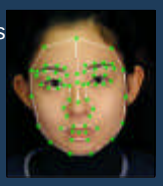
Expression mapping

Assumption:
Human faces have approximately the same normals

	Neutral	Expression
Person A:	I_a	I_a'
Person B:	I_b	$I_b' = \frac{I_a'}{I_a} I_b$

Image alignment

Manually mark face features



Use image warping to obtain pixel correspondence

Algorithm version#1

Input: Images A A' B

Step1: Mark feature points

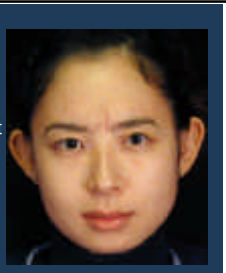
Step2: For each feature point v_b in B, warp it:
$v_{b'} = v_b + v_{a'} - v_a$
Let B_g be the warped image of B

Step3: Align A, A' with B_g by image warping.

Step4: Compute ratio image: $\Re = \frac{A'}{A}$

Step5: $B' = \Re \cdot B_g$

Filtering of ERI



Problem:
Noise due to pixel mis-alignment

Solution:
Adaptive Gaussian filter of ERI

For each pixel:
Step1. Compute weight: amount of deformation at this pixel
weight = 1 – ImageCorrelation(A, A')

Step2. Apply small-window Gaussian filter if weight is large
Apply large-window Gaussian filter if weight is small

Algorithm

Input: Images A A' B

Step1: Mark feature points

Step2: For each feature point v_b in B, warp it:
$v_{b'} = v_b + v_{a'} - v_a$
Let B_g be the warped image of B

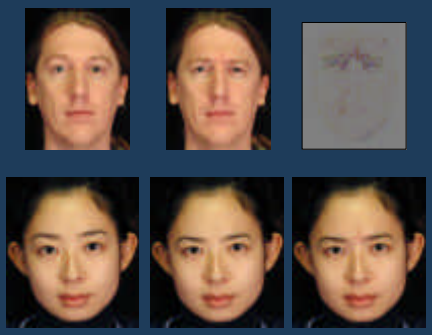
Step3: Align A, A' with B_g by image warping.

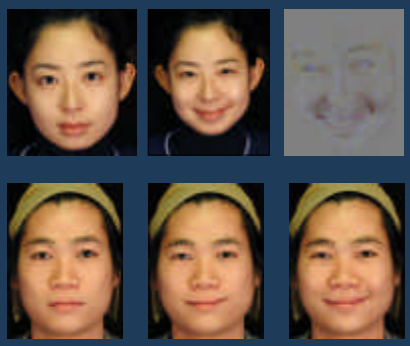
Step4: Compute ratio image: $\Re = \frac{A'}{A}$

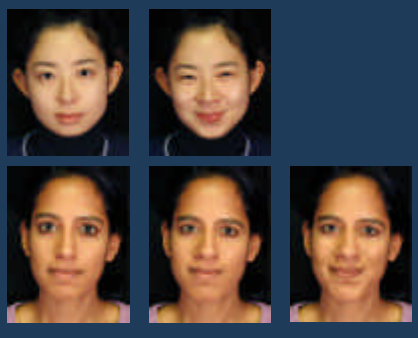
Step5: Filter $\Re$

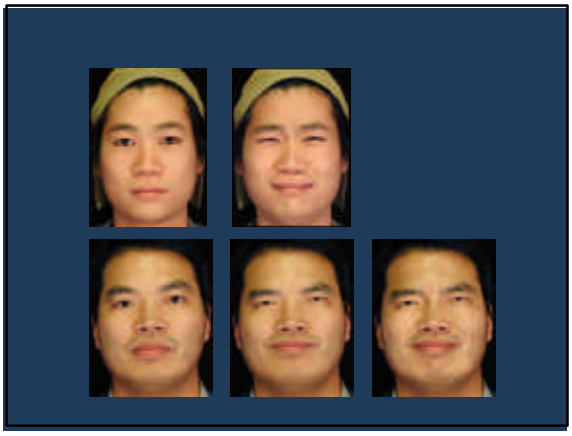
Step6: $B' = \Re \cdot B_g$

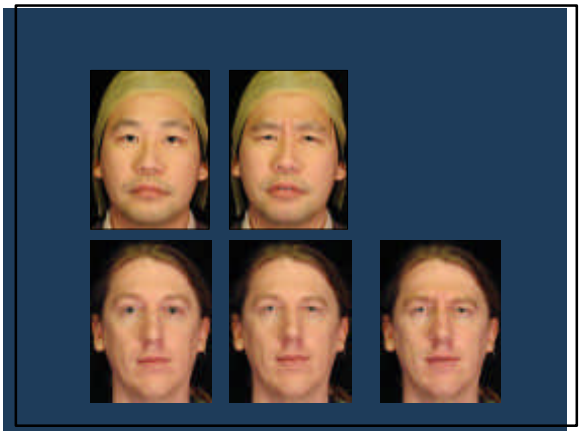
Results











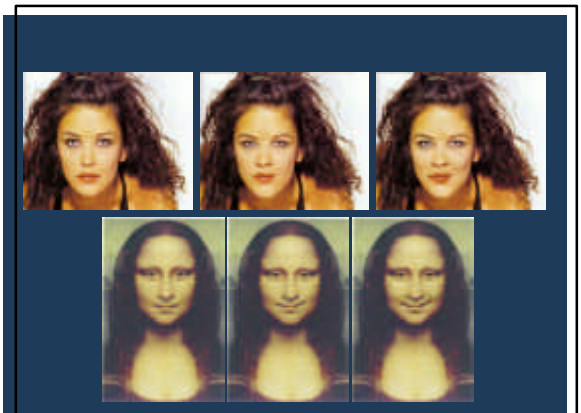
Different lighting conditions

Scale intensity of all the light sources: OK

Change lighting direction : No

Simple remedy:

- histogram matching
- use luminance ratio



Conclusion

Generate photo-realistic expression details

Enhance existing expression-mapping techniques:

- Difference vector + ERI = Convincing F.E.

Future work

Improve image alignment
- Line and curve features for image marking
- Better image warping algorithm

Expression toolkit
- Expressions of different people can be encoded as ERIs, and interpolated
- Generate desired expressions from a database of ERIs

Apply to other objects:
- Cloth?

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